



## Advanced Lead-Acid Batteries with Smart Carbon Technology – Africa Case Studies



# Topics

- Power in Africa
- State of the Art Manufacturing Process for High-quality Deep-cycle Batteries
- Introducing Smart Carbon™
- Compliance with Standards for Solar Batteries. IEC Test 61427
- Trojan batteries in the Field

# Power in Sub-Saharan Africa

- Sub-Saharan Africa has total installed capacity of Spain
- South Africa produces 2/3 of the continents power
- 90% of power supplied by coal-fired power stations
- Exporting only about 5% to other SADC countries
- Load shedding program implemented since rolling black-outs started in 2007
- 29% average of installed capacity unavailable
- 2084 MW currently produced by OCGT's for 16 hours p/d
- Production at 4.8 times cost of other power stations

# Power in Africa

	ELECTRICAL GRID	DIESEL GENERATOR	SOLAR ENERGY
<b>Technical reliability</b>	<b>Low</b> Blackouts, brownouts, outages, breakdowns, voltage drops, etc..	<b>Medium</b> Breakdown may be frequent due to mechanical parts.	<b>Excellent</b> Breakdown very rare. Grid outages avoided.
<b>Energy independence</b>	<b>Low</b> Centralised system	<b>Low</b> Problems with fuel supply (shortages, transport costs, etc.)	<b>Good to excellent</b> None (100% solar) to very low (hybrid) fuel dependency
<b>Social and economic benefits</b>	<b>Low</b> Benefits go to large electricity producers and distributors corporates	<b>Low</b> Fuel purchases cause a negative balance of trade .	<b>Excellent</b> Decisions and socio-economic benefits are local (education, jobs created, health, etc.)
<b>Impacts on health &amp; environment</b>	<b>Moderate to high</b> Greenhouse gases emissions by thermal power plants (coal, gas, fuel).	<b>High</b> Important greenhouse gases emissions and noise pollution	<b>Low to none</b> Green house gases emissions and noise pollution are low (hybrid) to inexistent (100% solar)
<b>Operation costs</b>	<b>Moderate to high</b> Ageing power infrastructures are often expensive and unreliable.	<b>High</b> Expensive fuel and maintenance costs.	<b>Low</b> Once the upfront investment done operation and maintenance costs are very low.
<b>Economic competitiveness</b>	<b>Varies with countries</b> Electricity wholesale prices vary from country to country due to governmental subventions, power generation facilities and natural resources..	<b>Low</b> Generator life cycle cost is very high due to short life time paired with expensive operation and maintenance costs.	<b>Good to excellent</b> Off-grid solar energy is 2 to 3 times cheaper than diesel generator. For large scale grid-connected plants, analysis must be done case-by-case.
<b>Energy cost volatility</b>	<b>High</b> In Africa, grid electricity prices are likely to increase in order to replace old infrastructures and increase generation capacity.	<b>Very high</b> Oil resources scarcity and demand increase will cause substantial market prices increase.	<b>None</b> Energy from the sun is free. Module performances are guaranteed over 25 years and the real lifetime is about 30 to 40 years.

# Quality Knows no Boundaries

- Legacy of building high quality “Made in the USA” batteries since 1925
- Exclusive focus on manufacture of deep cycle batteries; Flooded and VRLA
- A brand new state of the art production facility in the USA dedicated to VRLA batteries
- Distribution in over 100 countries worldwide, with 100+ domestic warehouses in the US
- A team of dedicated Telecom & Renewable Energy experts combined with battery expertise
- Third party lab testing showing that Trojan consistently outperforms the competition
- State of the art lean, ISO certified manufacturing facilities



## Sales presence in 120+ countries globally

OFFICES

CALIFORNIA  
GEORGIA  
UNITED KINGDOM  
DUBAI  
SOUTH AFRICA  
HONG KONG

**UNITED STATES/CANADA**  
A.A. Battery  
Battery Outfitters  
Battery Systems  
Factory Motor Parts  
Carolina Energy LLC  
Comvetrol Battery  
Magnacharge Battery  
Northeast Battery  
Safe-Start LLC  
Storage Battery  
Wholesale Battery Co. LLC

**CARIBBEAN**  
Caribbean  
Safe-Start LLC (B.S.)  
Alternative Power Systems  
Haiti  
Volcano-Lander S.A.

## MEXICO

**CENTRAL & SOUTH AMERICA**

**Brazil**  
Vielmo Jacó  
**Central and South America**  
Safe-Start LLC (U.S.)

**Chile**  
Emasa S.A.

**Colombia**  
Concord  
Acumuladores Duacoi

**Costa Rica**  
AFIL Innovaciones Energéticas S.A.  
Electric Cars of Costa Rica

**Guatemala**  
Compañía Comercial Libera, S.A.  
La Casa de los Rubíes S.A.

## Nicaragua

**EUROPE**  
Albania  
CIAK d.o.o.  
Austria  
Blumner GmbH  
Belgium  
Enzoo  
Baltic States

## EUROPE

Albania  
CIAA.d.a.  
Austria  
Banque Credit  
Belgium  
Ernst  
Baltic State

## Bosnia &amp; Herzegovina

**Bulgaria**  
Start Trading Ltd

**Croatia**  
CLAR Group

**Cyprus**  
Preston Exchange Ltd

**Czech Republic**  
Barron Rutter Ltd

**Denmark**  
Daxco International A/S

**Finland**  
Coltech

**France**  
Accor Plus

BEFUS, European Institutions, Services

## Germany

**Banner Batteries Deutschland GmbH**  
 Industrie Batterie Service  
**Greece**  
 Automotive Solutions  
 G.I. Kimerakis SA  
**Hungary**  
 Banner Batteries Magyarország Kft  
**Iceland**  
 Ols  
**Ireland**  
 Platinum Batteries (Europe) Ltd  
**Italy**  
 BPS Italia SRL  
**Luxembourg**  
 Ennos  
**Macedonia**

## Montenegro

BB-Elektronik D.O.O.  
Netherlands  
Emel  
Accounting Netix B.V.  
Norway  
Studio Design-Mark  
Portugal  
DUSA  
Romania  
CL&C dda  
WTE SPC  
Serbia  
BB-Elektronik D.O.O.  
Slovenia  
CL&C dda  
Spain & Spanish  
DUSA  
Sweden

## Switzerland

**Banner Batteries Schweiz AG**  
**Turkey**  
Sader  
**Ukraine**  
Acrionide Ukraine Ltd  
**United Kingdom**  
Platinum Batteries (Europe) Ltd

**MIDDLE EAST**  
**Egypt**  
Hydroturf International  
**Israel**  
Schnapp Batteries  
**Jordan**  
Hydroturf International  
**Kuwait**  
Kuwait Development and Trading  
Dabbashi

## Lebanon

Power Tech SARL  
**United Arab Emirates**  
 Hydrobat International  
**Yemen**  
 Al-Adnani Solar

**AFRICA**

**North Africa**  
 Hydrobat International

**South Africa**  
 First National Battery Co. Ltd.  
 Dixon Batteries (Benoni) Ltd.  
 Gulf Car Battery Suppliers (Pty) Ltd.

**West Africa**  
 Eastwell Nigeria Ltd.

**East Africa**  
 Centre for Alternative Technology

**Botswana**

## RUSSIA

**Moscow**  
Acizhade Plus Ltd.

**ASIA PACIFIC**

**Brunei**  
TMO Corp. Pte. Ltd. (Singapore)

**Cambodia**  
Gateway Equipment Co. Ltd.

**China**  
Dongguang EDA Technology Co.  
Gao: Fortune Co. Ltd.  
YH Co. Ltd. (Beijing)  
Xiamen Jellery Tech Co., Ltd.

**Hong Kong / Macau**  
Gerts Corporation Hong Kong

**India**  
Munak Engineering Services  
Mokibandan Duranai Private

## PT 100 Industry

**Japan**  
NISCO Corporation

**Malaysia**  
YIH (Malaysia) Sdn Bhd

**Nepal**  
Oasen Energy International Ltd

**Philippines**  
Kari Plaza Manufacturing  
YIH Philippines Inc.

**South Korea**  
Life General Machines Co. Ltd  
Tajin Instrument & Electric Co.

**Singapore**  
YIH Corp. Pte. Ltd. (Singapore)

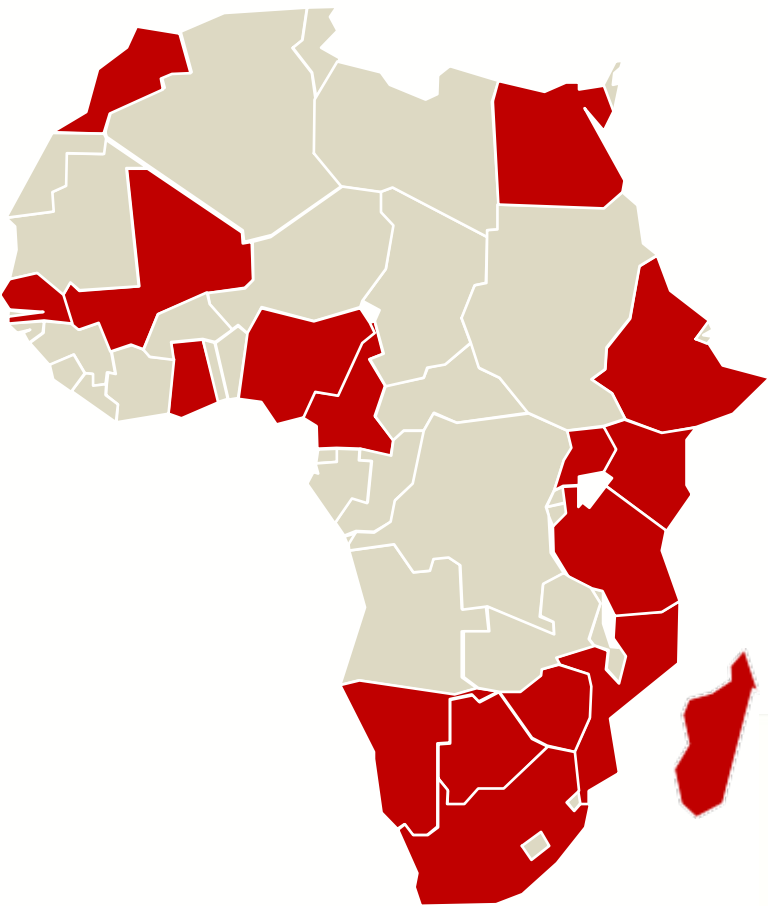
**Sri Lanka**  
YIH Corp. Pte. Ltd. (Singapore)

**Taiwan**  
ADRI International Ltd.

### Extreme Events

**AUSTRALIA / OCEANIA**  
Australia  
Also Battery Sales  
New Zealand  
Also Battery Sales

# Presence in Africa - updated



RE

## Successful with 5 Product Families



# Renewable Energy & Backup Power Applications

## Residential Renewable Energy Applications

Off-Grid Residential	Rural Electrification	Self-Consumption	Micro-Grids
Energy Storage Solutions for Off-Grid Buildings Secure Homes, Schools, and Specialized Buildings	Energy Storage Solutions for Rural Electrification Projects Safe, reliable power up to 100kW for homes, hospitals, schools, and other facilities	Available Energy Storage that helps you Store and Use the Energy from your Solar System 24/7, every day	Energy Storage for Unstable Grids Secure, reliable power for homes, schools, and other facilities
			

## Commercial & Industrial Applications

Remote Monitoring & Control	Solar Street Lighting	Telecom
Energy Storage Solutions for Remote Monitoring & Control Secure, reliable power for monitoring and control of critical equipment and infrastructure	Energy Storage Solutions for Off-Grid Solar Street Lighting Safe, reliable power for lighting, power, lighting, security lighting	Energy Storage Solutions for Off-Grid & Unstable Grid Telecom Networks Secure, reliable power for telecom networks and infrastructure
		

## Backup Power for Unstable Grids and Emergency Power

Inverter Backup	Grid-Tied Emergency Backup	Telecom
Energy Storage Solutions for Unstable Grids Secure, reliable power for homes, schools, and other facilities	Energy Storage Solutions for Grid-Tied Systems in Emergencies Secure, reliable power for homes, schools, and other facilities	Energy Storage Solutions for Off-Grid & Unstable Grid Telecom Networks Secure, reliable power for telecom networks and infrastructure
		

# State of the art facilities, automation and equipment

## Frost & Sullivan 2013 “Innovative Enterprise” Award

### Trojan Battery Receives Frost & Sullivan 2013 “Innovative Enterprise” Award

Trojan Battery Company, the world’s leading manufacturer of deep-cycle batteries, has been honored by industry research and consulting firm Frost & Sullivan and awarded its 2013 Manufacturing Leadership 100 Award (ML100) in the category of “Innovative Enterprise.”

Trojan Battery was recognized for its innovative use of technology and equipment at its Lithonia, Ga. manufacturing facility. Since the manufacture of deep-cycle batteries takes precision, accuracy and succinct methods to ensure the proper assembly of the delicate internal components, Trojan implemented specially designed Cast-On-Strap (COS) equipment to ensure the proper placement and connectivity of deep-cycle battery features, which ensures the highest level of product quality.

“Trojan Battery is honored to receive this prestigious recognition by Frost & Sullivan for the company’s advanced manufacturing processes,” said Gordon Beckley, senior vice president of engineering and quality assurance for Trojan Battery. “This award reinforces Trojan’s strategy of combining advanced manufacturing technology, premium components, and exacting standards for quality to ensure our batteries provide customers with the performance and reliability Trojan has become known for over the past 85 years.”



# Expertise in the entire battery manufacturing process, made in the USA with strict quality controls



Grid manufacturing / pasting



Plate curing chambers



Cell balancing and assembly



Battery formation



Finishing, cleaning and final QA

Approximately 570 hours to  
produce a high quality, deep  
cycle battery

# World leader in deep-cycle battery technology / R&D

Trojan has two of the largest and most extensive bi-coastal research & development centers dedicated to battery technology in North America

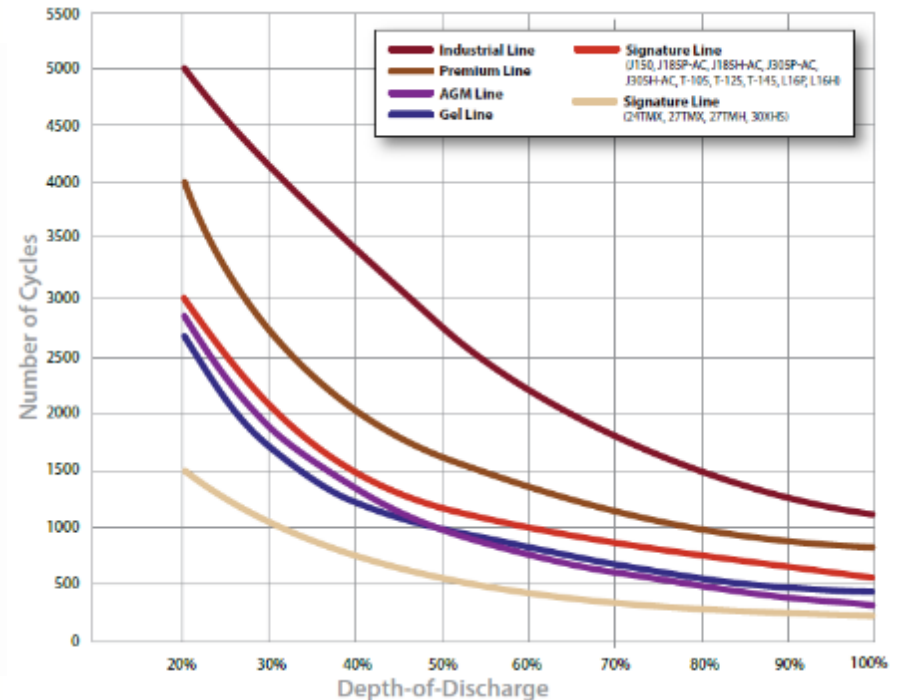
Intimate knowledge of charging technology and algorithms provides unique performance advantages for our OEM customers



Development teams backed by 30 years of proprietary process knowledge and combined deep cycle development experience of 120 years

On-going efforts encompass extending next generation technology to all battery product lines, continued value engineering and new product categories

# Renewable Energy Product Range



**Trojan Battery offers a broad portfolio of batteries, including Deep-cycle flooded, AGM and Gel VRLA batteries in monoblock and industrial sizes**

# Introducing Smart Carbon™

Trojan recently launched a new technology in its Industrial and Monoblock flooded battery product lines designed for Telecom & Renewable Energy applications which are cycled in a Partial State of Charge (PSOC).



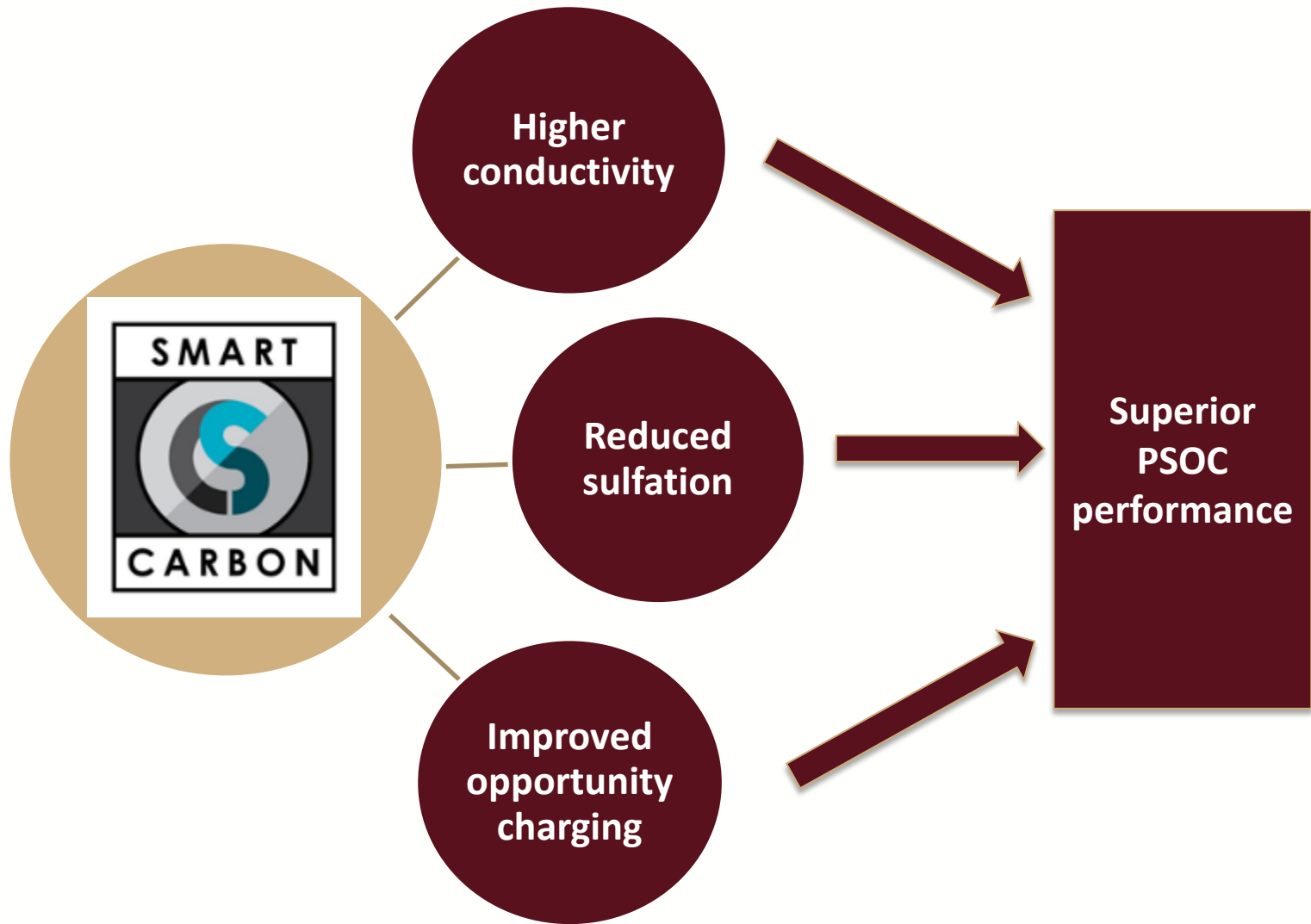
## Description of the Problem

- Lead-acid batteries need full recharge after each discharge for optimal cycling performance.
- Some cycling applications only partially recharge batteries, resulting in what is called **partial state of charge (PSOC)** cycling.
- PSOC cycling is a particular problem in renewable energy applications.
- PSOC cycling is harmful to the battery and leads to significant reductions in cycle life.

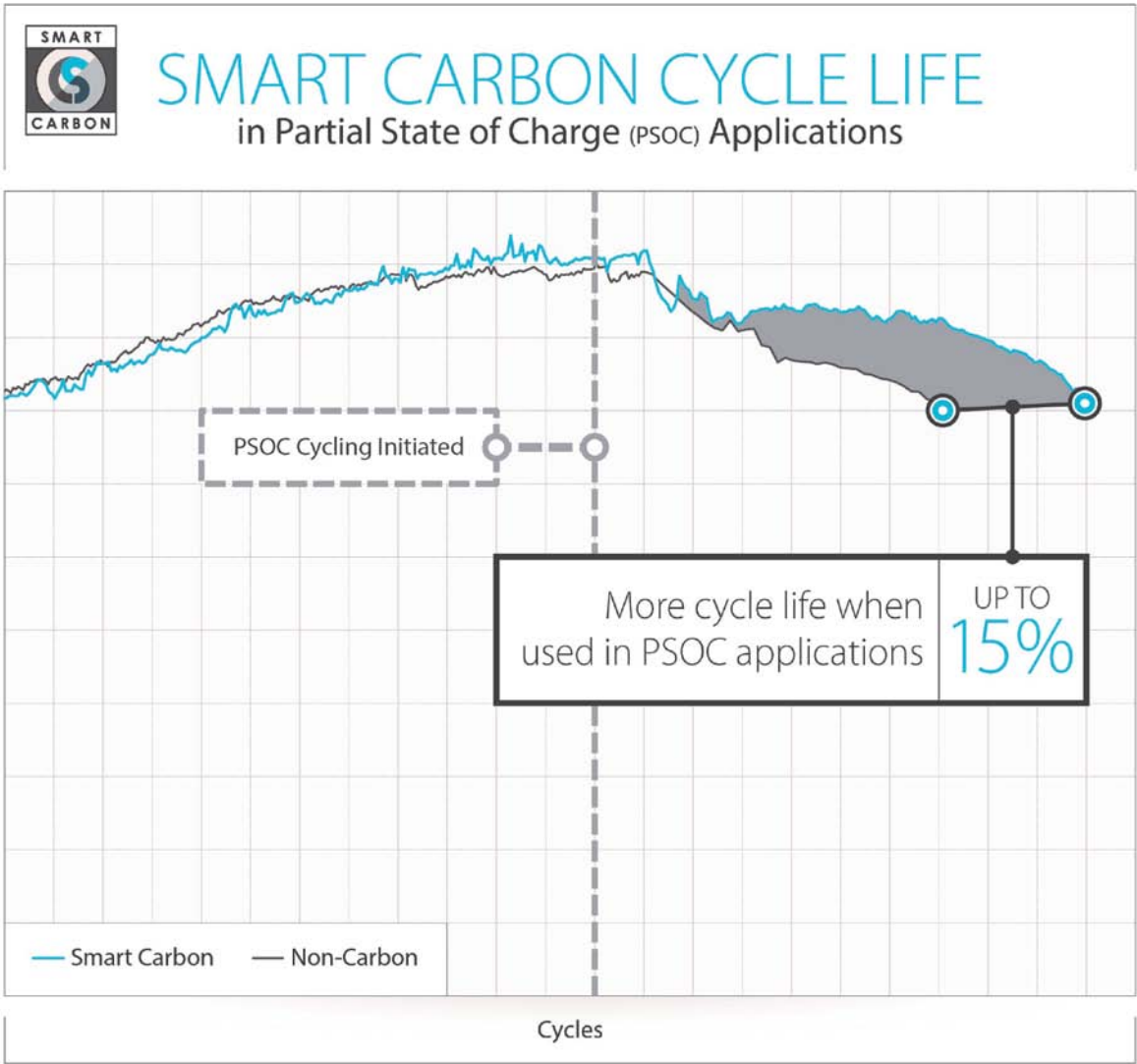
## Our Solution


- We focused on the failure mode of the batteries which was sulfation on the negative plate.
- Several years of R&D work took place to determine the best solution to keep Trojan batteries healthy when operating in PSOC applications.
- And Smart Carbon (SC) was created....

# Why Smart Carbon™ Is A Solution To The Problem



# Proving That The Smart Carbon Solution Works



The Benefits of Smart Carbon™ in PSOC Applications	
Scenario	Cycle Life at 50% DOD
Battery Operating at a Full State of Charge	2,800
Battery Operating in a Partial State of Charge Application(PSOC) without Smart Carbon	2,240
 Battery Operating in a Partial State of Charge Application (PSOC) with Smart Carbon	2,576

# Trojan Industrial Line – 17 years service life per the IEC 61427 test

## FLOODED LEAD ACID BATTERY TEST REPORT

(THIS TEST RESULT COVERS ALL BATTERY MODELS IN TROJAN BATTERY'S INDUSTRIAL PRODUCT LINE)

**Product group:** Flooded/wet lead acid cells with flat plates

**Type designation:** IND13-6V, 6V, 600Ah (10-hr rate) battery

**Endurance in cycles according to IEC 61427: 2005-05**

**Test, Chapter:** IEC 61427: 2005-5: Secondary cells and batteries for PV energy systems –

General requirements and methods of test

Chapter 8.4: Cycle endurance test in photovoltaic application (extreme conditions)

The Industrial battery reached its end of life after the 17th macro cycle, or after a total of 2,550 micro cycles. Because of the two factors mentioned in the previous paragraph (PSOC cycling and cycling at a continuous temperature of  $40^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ), each macro cycle that the battery successfully delivers is considered to be the equivalent of one year of service life for the battery.

Therefore, since the Industrial battery delivered 17 macro cycles before its delivered capacity dropped to under 80% of its rated capacity, we can say that Trojan Battery Company's Industrial battery line has a service life of 17 years, which is reflected in Table 3 below.

Finally, the results obtained from testing the IND13-6V model apply fully to all other Industrial models (current and future) by virtue of similarity of design.

Battery type	Equivalent service life
All Industrial models	17 years

**Note – this test was complete on the Industrial line batteries prior to the Smart Carbon additive. The Smart Carbon version is on test now**

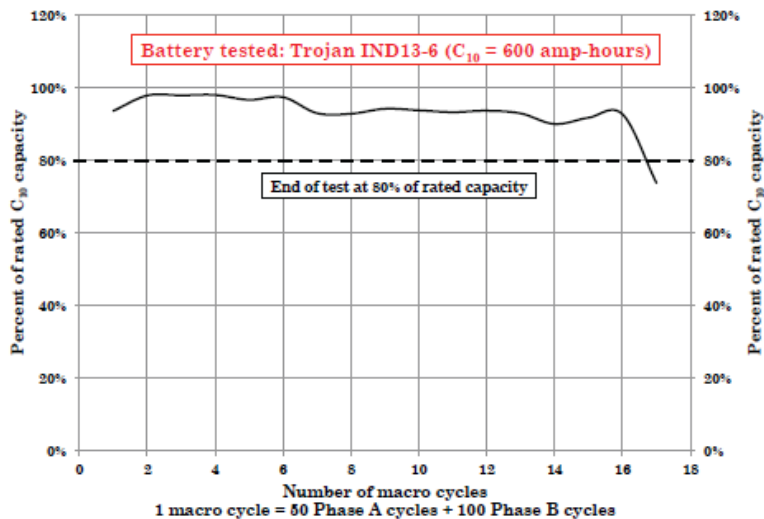


Figure 2: Percent capacity remaining after each macro cycle.

# Off-grid Solar Commercial

Center for Alternative Technology, Kenya  
Nature Reserve  
(24) Trojan IND17-6V



# Off-grid Solar Commercial

Omnisolar, South Africa  
Commissioned - 2015  
Off-grid lodge  
(48) Trojan IND33-2V



# Off-grid Solar Commercial

Kenya  
Off-grid electrification  
Commissioned - 2014  
(24) Trojan IND17-6V



# Off-grid Solar Commercial

Riwik - East Africa  
Power Back-up systems  
Commissioned - 2015  
J185-HAC



# Inverter Back-up

**Eauxwell Nigeria Limited, Nigeria**  
**Solar Powered Bank ATM Inverter Backup**  
**Commissioned - 2014**  
**(16) Trojan L16RE-B**



# Inverter Back-up

NewLord, Nigeria  
Inverter Backup – Intercontinental, Lagos  
Commissioned - 2015  
(120) Trojan J185P-AC



- Thank you
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